SYSTEM FOR ADAPTIVE RESENDING REQUEST CONTROL IN MOBILE RADIO COMMUNICATIONS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an adaptive resending request control system in mobile radio communications for controlling the data transmission speed in mobile radio communications in accordance with the state of a communication line to achieve the optimum transmission speed and delay characteristic that satisfy the required quality.

2. Description of the Prior Art

In conventional mobile radio communications, an error correction coding system for carrying out self-correction (hereinafter referred to as "FEC" (forward error correction)) and an automatic repeat request system for resending data from a transmission side when a data transmission error occurs at a reception side (hereinafter referred to as "ARQ" (automatic repeat request)) are known as a method of implementing error free data transmission. Further, a hybrid ARQ system comprising the combination of FEC and ARQ is also known.

For example, Japanese Laid-open Patent Publication No. Hei-7-67175 has proposed, as a prior art, a system of controlling the transmission speed stepwise in accordance with the line state (the line condition). Fig. 1 is a flowchart showing the control operation in this system.

Data transmission is started in control step 32, and it is judged in control step 33 whether the transmission speed is equal to the highest speed (9600 bps) or not. If the judgment in the control step 33 is "YES", then it is

judged in control step S34 whether there is any resending request or not. If there is a resending request, the resending processing is carried out in control step 35 and the resending frequency (the number of times of the resending) is counted. If it is judged in control step 36 that the resending frequency is equal to N or more, the transmission speed is decremented by one level in control step 37 and set to 4800 bps. Subsequently, resending frequency CNT is cleared in control step 38, storage memory is accessed in control step 39 and mode setting is carried out in control step 40. It is judged in control step 41 whether the transmission is finished or not.

If the judgment in the control step 33 is "No", it is judged in a control step 42 whether correction is impossible. If the judgment in the control step 42 is "Yes", it is judged in control step 44 whether the transmission speed is equal to 4800 bps which is lower than 9600 bps by one level. If the judgement in the control step 44 is "Yes", a resending request is made in control step 45. On the other hand, if the judgment in the control step 44 is "No", it is judged whether the transmission is finished or not as in the case of the control step 41. If the judgment in the control step 42 is "No", the correction processing is carried out as in the case of the control step 43.

In this system, when a burst error occurs, control steps of several stages are needed until the transmission speed reaches the optimum one because the transmission speed is stepwise controlled. Accordingly, this system has a disadvantage that the control thereof cannot sufficiently follow occurrence of a burst error. Further, the conventional technique has the following disadvantage. That is, since the resending control period is fixed, the delay time of the data resending cannot be controlled and thus the

optimum delay characteristic cannot be achieved in accordance with the line state. Further, there is no variation in the measuring method of the line state, and thus high-precision measurement cannot performed on some line states.

Furthermore, Japanese Laid-open Patent Publication No. Sho-64-42944 discloses a device for detecting a bit error rate by line quality detecting means and varying the coding rate in accordance with the detection result in a packet communication device having an error correcting function. According to this technical concept, the coding rate or the type of the coding is varied in accordance with the line quality, and if the line quality is excellent, the information amount is increased to achieve an effective use of the line. According to this system, the information speed is variable, however, the transmission speed is fixed.

Still furthermore, Japanese Laid-open Patent Publication No. Hei-7-336331 discloses a digital radio communication system having means of grasping the line state on the basis of the resending frequency or the bit error rate measured and changing the coding rate of the error correction coding in accordance with the line state. Further, with respect to a code division multiple access system (CDMA system), it also discloses a system for varying the coding rate in accordance with a traffic amount and a system of measuring the line bit error rate and varying the coding rate in accordance with the measurement result. As a result, it concludes that these systems can vary the coding rate to the optimum state in accordance with the line state and achieve the optimum throughput in the line state. In this case, there is a disadvantage that it takes a long time to grasp the line state on the basis of the resending frequency, and data of a predetermined pattern must be

transmitted before packet transmission in order to measure the bit error rate.

SUMMARY OF THE INVENTION

Therefore, an object of the present invention is to provide an adaptive resending request control system (in mobile radio communications) that has a function of controlling the data transmission speed more flexibly to thereby achieve the optimum transmission speed satisfying required quality even when a burst error occurs, making variable a window size for controlling data resending, that is, a resending control period to thereby control the delay characteristic of the data resending and achieve the optimum delay characteristic corresponding to a line state, and selecting a line state measuring method having the highest precision in accordance with the line state of a radio section, whereby a high-precision line state measurement is performed.

In order to attain the above object, according to a first aspect of the present invention, there is provided a system for an adaptive resending request control in mobile radio communications, comprising:

(a) measuring means for measuring a line state of a line of a radio section, first selecting means for selecting a control state of a coding rate in correspondence with the measurement results on the basis of the measurement results, and means for renewing the control state and transmitting the control data on the control state to a transmission side, in a reception side; and

(b) second selecting means for selecting the coding rate in correspondence with the received control data on the basis of the received control data, and means for generating data with the selected coding rate and

transmitting the generated data to the reception side, in a transmission side.

Further, in order to attain the above object, according to a second aspect of the present invention, there is provided a system for an adaptive resending request control in mobile radio communications, comprising:

(a) measuring means for measuring a line state of a line of a radio section, first selecting means for selecting a control state of a packet resending control period in correspondence with the measurement results on the basis of the measurement results, and means for renewing the control state and transmitting the control data on the control state to a transmission side, in a reception side; and

(b) second selecting means for selecting the packet resending control period in correspondence with the received control data on the basis of the received control data, and control means for controlling a packet resending control period to the selected packet resending control period, in a transmission side.

Further, in order to attain the above object, according to a third aspect of the present invention, there is provided a system for an adaptive resending request control in mobile radio communications, comprising:

(a) measuring means for measuring a line state of a line of a radio section, first selecting means for selecting a control state of a coding rate and packet resending control period in correspondence with the measurement results on the basis of the measurement results, and means for renewing the control state and transmitting the control data on the control state to a transmission side, in a reception side; and

(b) second selecting means for selecting the coding rate and packet

resending control period in correspondence with the received control data on the basis of the received control data, means for generating data with the selected coding rate and transmitting the generated data to the reception side, and control means for controlling a packet resending control period to the selected packet resending control period, in a transmission side.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a control flowchart of a conventional resending request control system;

Fig. 2 is a system construction of an adaptive resending request control system based on a coding rate variable system;

Fig. 3 is a system construction of an adaptive resending request control system based on a period variable system;

Fig. 4 is a system construction of an adaptive resending request control system based on a coding rate variable and period variable system;

Fig. 5 is a control flowchart of the adaptive resending request control system based on the coding rate variable system at a data reception side;

Fig. 6 is a control flowchart of the adaptive resending request control system based on the coding rate variable system at a data transmission side;

Fig. 7 shows an example of an association table to be stored in data storage portion 2 in Fig. 2;

Fig. 8 shows an example of an association table to be stored in data storage portion 6 in Fig. 2;

Fig. 9 is a state transition diagram when the control state of the adaptive resending request control system based on the coding rate variable system is renewed;

Fig. 10 is a block diagram showing the construction of a line state monitoring portion of Fig. 4;

Fig. 11 is a control flowchart of the adaptive resending request control system based on the coding rate variable and period variable system at the data reception side;

Fig. 12 is a control flowchart of the adaptive resending request control system based on the coding rate variable and period variable system at the data transmission side;

Fig. 13 shows an example of an association table stored in data storage portion 12 of Fig. 3;

Fig. 14 shows an example of an association table stored in data storage portion 16 of Fig. 3; and

Fig. 15 is a state transition diagram when the control state of the adaptive resending request control system based on the period variable system is renewed.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of an adaptive resending request control system in mobile communications according to the present invention will be described with reference to the accompanying drawings.

First, a system construction suitable to implement each system of the present invention will be described hereunder with reference to Figs. 2 to 4.

Fig. 2 shows a system construction when coding rate variable resending request control for making variable the coding rate of date in accordance with the line state (the line condition) is performed.

At a data reception side, reception data are input to line state

monitoring portion (line condition monitoring portion) 1 to measure the line state. The measurement result is input to comparator 3 and compared with data readout from data storage portion 2 to select the optimum control state from the data of the control states stored in the data storage portion 2 and renew the control state. Subsequently, control data are generated on the basis of the control state renewed in control data generator 5, and then transmitted to a data transmission side.

At the data transmission side, the control data received are stored in control state storage portion 7. The control data thus stored are compared with data read out from a data storage portion 6 at comparator 8 to renew the coding rate. Subsequently, data are generated in accordance with the coding rate thus renewed and then resent.

In the line state monitoring portion 1 at the data reception side a, the line state is measured by using one or both of SIR measurement and packet arrival rate measurement, or other methods. Here, the packet arrival rate means the ratio of the number of error-correctable packets arriving at the data reception side to the number of packets transmitted for a fixed time from the data transmission side. The association table of the line state measurement values, the coding rates and the control states are stored in the data storage portion 2. The association table of the coding rates and the control states is stored in the data storage portion 6. The ARQ system at this case is assumed to be Stop-and-wait or Go-back-N Continuous ARQ, or Selective-repeat continuous ARQ.

Fig. 3 shows the system construction of a period-variable resending request control system for making the resending period of data variable in

accordance with the line state.

At the data reception side of this system construction, reception data are input to line state monitoring portion (line condition monitoring portion) 10 to measure the line state. The measurement result is input to comparator 11 and compared with data read out from data storage portion 12 to select the optimum control state from the data of the control states stored in the data storage portion 12 and renew the control state. Subsequently, control data are generated on the basis of the renewed control state in control data generator 14, and then transmitted to the data transmission side.

At the data transmission side, the control data are received, and stored in control state storage portion 15. The control state thus stored are input to comparator 17 and compared with data read out from data storage portion 16 to renew the resending control period. The data thus renewed are transmitted to resending control period controller 18 to control the resending control period.

The association table of the line state measurement values, the resending control periods and the control states is stored in the data storage portion 12 at the data reception side. The association table between the resending control period and the control state is stored in the storage portion 16. The ARQ system at this time is assumed to be Go-back-N Continuous ARQ, or Selective-repeat Continuous ARQ.

Fig. 4 shows the system construction of an adaptive resending request control system for making both of the data coding rate and the resending control period variable in correspondence with the line state. In this system construction, at the reception side, reception data are input to line state

monitoring portion (line condition monitoring portion) 19 to measure the line state. The measurement result is input to comparator 20 and compared with data read out from data storage portion 21 to select the optimum control state from the data of the control states stored in the data storage portion 21 and renew the control state. Subsequently, control data are generated in control data generator 23 on the basis of the renewed control state, and then transmitted to the data transmission side.

At the data transmission side, the control data are received and stored in control state storage portion 24. The control data thus stored are input to comparator 25 and compared with data read out from data storage portion 26 to renew the resending control period. The renewed data are transmitted to resending control period controller 28 and control the resending control period. Further, the coding rate is renewed and the renewed data are transmitted to data generator 27, and data are generated on the basis of the coding rate thus renewed and resent.

The association table of the line state measurement values, the data coding rates, the resending control periods and the control states are stored in the data storage portion 21 of the data reception side. The association table of the data coding rates, the resending control periods and the control states is stored in the storage portion 26. The ARQ system at this case is assumed to be Go-back-N Continuous ARQ or the Selective-repeat Continuous ARQ.

As described above, according to the present invention, the resending control period of data is made variable in accordance with the line state of the radio section, or both the data coding rate and the data resending control period are made variable in accordance with the line state of the radio

section.

Further, according to the present invention, the control is performed so that any one of the SIR measurement result or the packet arrival rate can be selected from the reception data in accordance with the line state, so that any one or both of the throughput characteristic and the delay characteristic optimal to the line state can be enhanced.

According to the system construction of Fig. 2, the data reception side includes the line state monitoring portion 1 for receiving reception data and outputting an SIR measurement result from the reception data, the data storage portion 2 for storing the data to be compared with the measurement result, the comparator 3 for receiving the data read out from the data storage portion 2 and the SIR measurement result to compare both the data and the result and outputting a control state, the control state storage portion 4 for storing the control state, and the control data generator 5 for receiving the control state and outputting the control data. The data transmission side includes the control state storage portion 7 for storing the control state, the data storage portion 6 for storing data to be compared with the control data stored in the control state storage portion 7, the comparator 8 for receiving the control data and the data read out from the data storage portion 6 to compare both the data and outputting the data of the coding rate, and the data generator 9 for receiving the data of the coding rate and outputting the data.

Figs. 5 and 6 are control flowcharts at the data reception and transmission sides for the coding rate variable resending request control system when the line state monitoring portion carries out SIR measurement.

In Fig. 5, SIR is measured in control step 2a, and the measurement value and the association table are compared with each other by using the association table stored in the data storage portion 2 in control step 3a.

In this embodiment, the association table of Fig. 7 is assumed to be used. The error correction coding is set to a 8-value soft decision Viterbi decoding. For example, if the measurement value of SIR is equal to 10 dB, control state S11 under which the coding rate is equal to 7/8 is selected on the basis of the association table. The control data under the control state S11 are transmitted to the data transmission side. Subsequently, if SIR is measured and the measurement value thereof is equal to 12 dB, control state S11 is selected from the association table to renew a control state to the control state S11. If the measurement value is equal to 7.5 dB, control state S12 is selected from the association table to renew a control state to the control state S12. If the measurement value is equal to 5 dB, control state S13 is selected to renew a control state to the control state S13. The control state is renewed in control step 4a of Fig. 5, and control data are transmitted in control step 5a.

When the control data are received in control step 2b of Fig. 6 at the data transmission side, the control data and the association table of Fig. 8 stored in the data storage portion 6 are compared with each other in control step 3b. The control state is renewed in control step 4b, and data are generated on the basis of the coding rate of the renewed control state in control step 5b. The data are transmitted in control step 6b. Fig. 9 is a state transition diagram to renew the control state of the coding rate variable resending request control system.

The basis construction is as described above, however, in this

embodiment the line state monitoring portion may be further improved. The improved construction of the line state monitoring portion is shown in Fig. 10.

In Fig. 10, after the measurement of the number of packet reception, the line state can be more surely grasped by performing such a switching control operation that the packet arrival rate is measured if the packet reception number is equal to a threshold value k or more and the SIR measurement is carried out if the packet reception number is less than the threshold value k.

Next, the construction and operation of the above embodiment will be described.

Referring to Fig. 3, the data reception side includes the line state monitoring portion 10 for receiving the reception data and outputting one of the SIR measurement result and the packet arrival rate from the reception data, the data storage portion 12 for storing the data to be compared with the measurement result, the comparator 11 for receiving the data read out from the data storage portion 12 and the measurement result to compare both the data and the result and outputting the control state, the control state storage portion 13 for storing the control state and the control data generator 14 for receiving the output of the control state storage portion 13 and outputting the control data.

The data transmission side of Fig. 3 includes the control state storage portion 15 for storing the control state, the data storage portion 16 for storing the data to be compared with the control data, the comparator 17 for receiving the control data and the data read out from the data storage portion

16 to compare both the data and outputting the data of the resending control period, and the resending control period controller 18 for controlling the window size of the resending control.

Figs. 11 and 12 are control flow diagrams of the period variable resending request control system according to the embodiment of the present invention in which the line state monitoring portion shown in Fig. 3 performs the packet arrival rate measurement or the SIR measurement selectively. As shown Fig. 11, at the data reception side, when receiving the data, the number of packet reception for a fixed time is measured in control step 8a. If the packet reception number is equal to a threshold value k or more, the packet arrival rate is measured. On the other hand, if the packet reception number is less than k, the SIR is measured, whereby the line state can be surely grasped. In control step 10a and 12a, the measurement value and the association table (as shown in Fig. 13) stored in the data storage portion 12 are compared with each other.

For example, if the packet arrival rate is equal to 0.9, S21 is selected and the control data are transmitted. The measurement of the packet arrival rate is started again, and if the packet arrival rate is equal to 0.9 as shown in Fig. 13, S21 is selected to renew the control state to S21. If the packet arrival rate is equal to 0.7, S22 is selected to renew the control state to S22. If the packet arrival rate is equal to 0.4, S23 is selected to renew the control state to S23. In control step 14a, the control data are transmitted.

At the reception side, the control data are received in control step 9b of Fig. 12, and the control data and the association table of Fig. 14 are compared with each other in control step 10b. In control step 11b, the control

state is renewed , and the resending control period is controlled on the basis of the renewed data in control step 12b. Fig. 15 is a state transition diagram when the control state of the period variable resending control system of this embodiment is renewed.

Fig. 4 is a system diagram showing another embodiment in the adaptive resending request control system according to the present invention. Referring to Fig. 4, the data reception side includes the line state monitoring portion 19 for receiving the reception data and outputting one of the SIR measurement result and the packet arrival rate from the reception data, the data storage portion 21 for storing the data to be compared with the measurement result, the comparator 20 for receiving.the data read out from the data storage portion 21 and the measurement result to compare both the data and the result and outputting the control state, the control state storage portion 22 for storing the control state, and the control data generator 29 for receiving the output of the control state storage portion 22 and outputting the control data.

Further, the data transmission side of Fig. 4 includes the control state storage portion 24 for storing the control state, the data storage portion 26 for storing the data to be compared with the control data, the comparator 25 for receiving the control data and the data read out from the data storage portion 26 to compare both the data and outputting the data of the resending control period, the data generator 27 for generating the data on the basis of the output of the comparator, and the resending control period controller 28 for controlling the window size of the resending control. In this embodiment, the data coding rate and the data resending control period are made variable in

accordance with the line state as described above, and more effective adaptive resending request control can be implemented.

As described above, the present invention has the following effects. That is, a first effect resides in that the data coding rate and the data resending control period are made variable in correspondence with the line state of the radio section, so that the optimum throughput characteristic and the optimum delay characteristic can be provided in accordance with the line state. Further, a second effect resides in that the plural measuring methods are provided and the highest-precision measuring method can be selective from the plural measuring methods in accordance with the line state of the radio section, so that the high-precision line state can be grasped and the more effective adaptive resending request control can be performed.